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Original Article

Real-Time Dimension Detection using Customized Canny Edge Detection Algorithm

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Abstract *- Computer vision is a subset of Artificial Intelligence utilized to extract informative data from images. It offers a variety of features, including image categorization, edge detection, and object identification. Edge detection is particularly helpful in a variety of fields, including construction, agriculture, manufacturing, autonomous cars, and facial recognition. The system can obtain object edges and determine an object's dimensions by applying various edge detection operators while using opencv. The edges are the fundamental issue with dimension detection. One of the key aspects of the image that might provide us with highly helpful information about an object is its edges. Despite the fact that edge detection is an extremely ancient subject, no thorough research has been done to clarify which edge detection technique will work the best for dimension recognition. The paper introduces a Customized Canny Edge Detection Algorithm (CCEDA) for real-time object processing, eliminating the need for a dataset. To improve the performance of the canny edge detector, the operator combines bilateral filtering with morphological operations like dilation and erosion. Metrics including Signal Noise Ratio (SNR), Structural Similarity Index Measure (SSIM), entropy, Peak Signal to Noise Ratio (PSNR), and Mean Squared Error (MSE) are used to evaluate the modified canny edge detector's performance. The accuracy for dimension detection is reported to be 92.01%.*

Keywords *- Edge detection, Dimension detection, Image segmentation, Canny edge detector.*

1. Introduction

The term "dimension detection" refers to one of the best methods in the industry to identify an object's dimensions in real-time so that the cost of industrial aid administration can be decreased. The paper provides a customized canny edge detector to recognize the better-performing one to obtain sharp object edges. As mentioned earlier, this undertaking demonstrates an approach for immediately calculating measures from images. In order, it makes use of a web camera to find the object. After recognizing the object, it employs an edge detector operator to show real-time measurements on the connected devices.

Implementing this approach has a number of advantages, including the fact that it is visibly helpful in the industrial domain and simplifies human labour. The reference object must be chosen before any item's measurements are determined. In this instance, it is the aruco marker. The object dimension is then provided as an output after measuring the item's dimensions in comparison with the reference object [5].

An image is created by several aspects, including size, colour, orientation, and object features. The structure of the objects, which its contours may determine, is the main concern for dimension detection; nevertheless, the item's edges must be identified to find contours [24]. This paper provides an edge detection algorithm to be used as the dimension detector to discover the image's [6].

2. Literature Review

When determining if components or products have been constructed or laboured upon in line with desired standards, dimension detection is an essential aspect to understand. Dimension detection is mostly used in civil companies. Real-time dimension detection fulfils image processing that enables real-time dimension detection of objects. F.Chen et. al. have provided a greater high-quality approach for figuring out the neighbourhood fractal dimensions. They have provided zero as a substitute value if data is lacking. You should repeat a few values when certain that the boundary pixel neighbours in the nearby home windows are no longer available. The primary drawback of this technique is that it cannot detect edges on surfaces with uniform texture [1]. Israni S. et al. focused on edge licence plate detection. By-product approximation was utilized to recognize image edges and detect aspects using a sobel operator. The sobel operator has the advantage of reducing the random noise in the image. The authors' decision to only consider indications and ignore the noise associated with the operators is a drawback [2]. A previously enhanced method for image edge detection has been introduced by Hanmin Yeet et al. To enhance the algorithm's overall resistance to noise, they combine BM3D and prewitt operator denoising. The prewitt operator has a few uses since it is simple to calculate, but its poor anti-noise performance is a drawback [3]. Sobel edge detection for face attention, which uses the edges from digital photos to identify faces, has been thoroughly evaluated by Achal Sharma et al. The Sobel edge detection method's main component is the horizontal and vertical convolution of the image's pixels. They are difficult to comprehend complex edges in this situation [4]. An improved strategy for accurately recognizing objects as well as learning their true temporal dimension has been put forth by Shweta Pardeshi et al. They used a set of AI and IoT technologies, including webcam and opencv. To capture images using a canny edge detector, they employed a camera and white paper archives [5]. A more accurate approach to recognizing wise edges has been developed by G. Xin et al. This idea emerged from the fact that colour pictures did not work with conventional canny edges. The authors proposed an approach that uses a quaternion-weighted common filter, vector sobel gradient computation, and interpolation-reliant non-maxima suppression. The main limitation in this case is the amount of expensive the proposed method is to compute [6]. The 5 x 5 Sobel kernel has been implemented by Theodora Sanida et al. using OpenCV. In basic terms, they completed the experimental study and contrasted the outputs of each three x three and five x five kernel [7]. An adjustable median filter technique was employed by L. Cao et al. to remove noise from the clothing image. They used an instant fuzzy edge-detection method to become aware of the edges of garment images.

To find the nook spots, they also employed a Freeman code-based technique. Using an adaptive median filter, they have successfully removed all impulsive and non-impulsive noise from images. The computational cost of this strategy is high [8]. The Laplacian of the Gaussian operator, the canny operator, and the modified sobel operator were employed by Y. Zhang et al. to enhance the effects of edge detection. Using morphological smoothness and other photo fusion techniques reduces noise from photos [9]. Fractional order derivatives based mostly on sobel, prewitt, and Laplacian operators have been proposed by Jayshree Deka et al. With the use of MSE, PSNR, SSIM, and FSIM—the four measures employed in the picture nice assessment (IQA) process—they assessed the overall performance of their device using a collection of photos of freshwater fish [10].

Looking up agreeable operators to understand the personality of the word lontara in Sanskrit texts was suggested by Yolanda Ferandji et al. The writers of this search have utilized both good and bad photo quality. The MSE metric was originally used to gauge an operator's overall performance, but this result only applies in a few situations [11]. P. Prathusha et al. used morphological operation and covering to promote an accelerated sobel, prewitt, and robert operator. The edges that are in vain are eliminated, and thick images are supplied to the crab photographs. In essence, they compared more favourable operators with older ones and found that the former are much superior [12]. A. Jain et al. have studied a variety of operators and severe facet detection techniques. They have shown that bio-stimulated algorithms outperform conventional algorithms [13]. In order to find fruits, Md. Khurram et al. proposed techniques for extracting shadow and structure. Utilizing canny edge detection, fruits are identified and sorted [14]. A method that expedited canny impediment edge detection has been suggested by Hongli Lu et al. By using this approach, one may obtain a more accurate impediment edge, which is essential for eliminating wall-cleaning robot limits [15]. However, in this case, the selection of gradient templates frequently depends on previous data.

3. Methodology

The canny edge detector is customized in such a way that it finds the edges of the image of strong-fashioned objects and consequently helps to discover contours. Canny extracts the edges effectively in contrast to different edge detection operators. Image pre-processing like gray scale conversion and blur filter must be utilized to make the image in an appropriate shape for the canny edge detector. In contrast to the above, the overall performance of one-of-a-kind edge detection algorithms with our personalized canny aspect detector with metrics such as SNR, PSNR, SSIM, MSE and entropy. The modified canny algorithm replaces Gaussian blur with bilateral filtering and includes morphological operations like dilation and erosion after hysteresis thresholding for edge detection.

3.1. Sobel Operator

Edges can be extracted by making adjustments in the intensity of the pixel. Edges can be marked as they will examine the variations in depth of adjacent pixels [25-27]. Sobel area detection uses two masks, one useful for identifying the vertical aspect, the other for determining the horizontal side, and both work to identify and calculate the effects of the gradient in both the vertical and horizontal axes [5].

3.2. Prewitt Operator

Detection of edges is finished with the prewitt operator. With calculation, the distinction between adjacent pixels' brightness in an image and edges may additionally be determined. It is the first by-product operator which makes use of the idea of spin-off masking. As a photo, when being signalled to exchange in a signal, that sign can be gauged by the usage of differentiation. Consequently, this is stated to be a spin-off operator or spin-off mask [9, 10].

All spin-off masks must comprise beneath features:

- Masks ought to encompass contrary signs.
- The total sum of both masks must equal to zero.
- As the weight will increase, edge detection receives better.

3.3. Robert Operator

By robert move operations, it becomes effortless and environment-friendly to calculate the gradients' twodimensional measurements on the image. Because of this, it will provide insights into the larger spatial frequencies associated with edges. The measured pixel values display the predicted values of the enter's spatial gradients at a certain place [11]. On paper, it has convolution kernels of the two operators, Robert and sobel operator have comparable working.[10]

3.4. Canny Edge Operator

With the use of the canny aspect detection technique, the quantity of records that wish to be processed can be notably decreased whilst nevertheless extracting beneficial structural facts from a range of imaginative and prescient objects. It is often used in one-of-a-kind laptop imaginative and prescient systems.

According to canny, the necessities for making use of aspect detection for more than a few imaginative and prescient structures are generally the same. Thus, an answer for side detection that meets these wants can be used in a range of contexts.

Following are the steps of the algorithm [9]:

- Grayscale conversion
- Noise discount the usage of Gaussian filter
- Gradient calculation
- Non-maximum suppression
- Double thresholding
- Edge monitoring the usage of hysteresis
- Cleaning up

3.5. Laplacian of Gaussian

Laplacian are spin-off filters. Noise affects the derivative filters; therefore, it is vital to smoothen photographs with the usage of Gaussian filters earlier than the use of Laplacian. This technique is recognized as Laplacian of Gaussian. It uses the 2D derivative of a picture. When Gaussian Laplacian is used, it will offer [10]. Lighter aspects will respond negatively, while the darker side will respond positively. If there is a sharp region between any two provided areas, the result will change. via Laplacian of Gaussian is –

- outcome is zero if it is far from the edge.
- outcome is high-quality if it is simply to the one edge of it.
- outcome is poor if it is simply to be the different aspect of it.

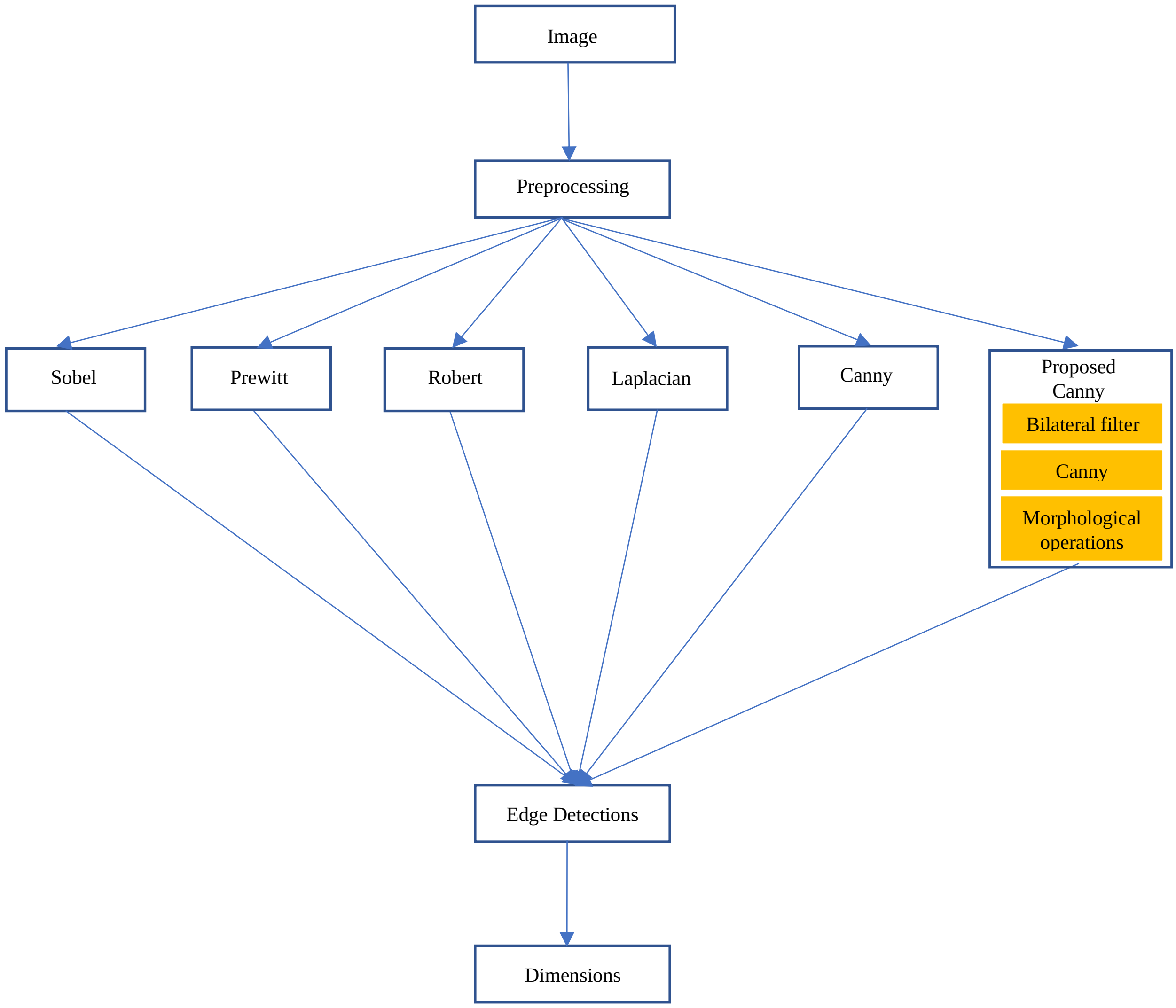

Fig. 1, Block diagram

An image's edges can provide us with a great deal of information about the object. No solid studies have been done that tell if there is a sharp boundary between any two provided regions, the result will change, despite edge detection being an old topic. Here, a customized canny edge detector operator is presented for real-time object processing, eliminating the need for a dataset. The operator employs bilateral filtering and morphological operations like dilation and erosion for enhanced detection performance.

4. Proposed System

4.1. Image Pre-Processing

The captured image from the webcam is taken through exceptional pre-processing methods to make certain the images are in the proper shape for the approach to operate. Pre-processing, like grayscale conversion, is utilized to make certain the operation is computationally much less highly-priced, and a bilateral filter is utilized on the grey scale picture to decrease the noise.

A bilateral filter is a non-linear, edge-preserving, noise-reduction smoothing filter for images. This replaces the depth of every pixel with weighted common depth values from close-by pixels. A Gaussian distribution can serve as the primary base for this weight. Bilateral filtering is a superior model of Gaussian blurring. Blurring produces no longer solely dissolving noises; smoothing edges and bilateral filters can maintain sharp edges whilst disposing of noises.

4.2. Gradient Calculation

The step tends to concentrate on an intensity and an edge way. The Sobel filter is used to identify gradients. Additionally, edges will become visible when a picture's colour is changed so that the depth of pix additionally changes. Both x and y, i.e. horizontal and vertical observations of depth variants, are made.

The derivatives, i.e. ix and iy, with recognition of x and y, are calculated when the photo is smoothened. This is accomplished by combining it with the horizontal kx and vertical ky of the sobel kernel.

Sobel Kernals:

$$\mathrm{K_x} = [-1\ 0\ 1\ \ -2\ 0\ 2\ \ -1\ 0\ 1\,]$$

$$\mathrm{K_y} = [1\ 2\ 1\ \ \ 0\ 0\ 0\ -1-2-1\,]$$

After using these kernels, the slope and magnitude, i.e. θg of the gradient, are computed.

$$|G| = \sqrt{I_x^2 + I_y^2}$$

$$\theta(x, y) = (\frac{I_y}{I_x})$$

4.3. Non-Maximal Suppression

The extracted edges are tons thicker prior to this step, but in the closing photo or resulting picture, they must have skinny edges. The edges are widened, and the usage of non-maximum suppression. Perfect cost pixels in the edge instructions are located with the aid of iterating from all the factors on the gradient depth matrix. It will find two neighbours on every pixel in superb as proper as bad gradient directions.

4.4. Threshold Calculation

The essential intention of this stage is to find three classes of pixels—stronger, weaker, and irrelevant. Here, the magnitudes of the gradient contrast two threshold values. The very first is a decrease to the other. The stronger pixels have excessive depth and are regarded as the closing edge. Weak pixels no longer have a good deal of depth to be regarded as robust ones; however, they have a lot of depth to no longer be viewed as of no importance pixels.

The difference from this is that there are no non-applicable pixels. A higher threshold is thought to find the strong pixels. For all pixels whose intensities are between the higher and lower thresholds, the hysteresis approach (the next step) will enable us to determine which pixels are large and which are irrelevant.

4.5. Hysteresis Thresholding

This works on the result produced by way of threshold if and solely if susceptible pixels will be transformed to sturdy pixels, the pixel around that vulnerable pixel is sturdy. After this, the pixels viewed for the closing area map need to be observed.

4.6. Morphological Operation

The Edge photograph would be handed to a morphological characteristic, which would take the picture through Dilation and Erosion.

Morphological dilatation, which provides more sight and fills in microscopic gaps in things, is how they are produced. Lines appear thicker, and tightly packed forms appear bigger. The resulting pixel's cost equals the lowest cost of all the pixel neighbours. If any nearby pixels have a zero cost, the pixel in a binary picture is set to zero.

Morphological erosion removes floating pixels and thin lines, leaving only large objects. The remaining traces show up thinner, and shapes show up smaller. The following discernment illustrates the dilation of a binary image. The structuring issue defines the neighbourhood of the pixel of interest, which is circled.

4.7. Contours and Dimension Calculation

The final Edged image given by morphological operation is used to extract contours. A simple approach to defining a contour is a curve connecting all the continuous points (along the border) with the same colour or intensity. Contours are a helpful tool for form analysis, object identification, and object recognition.

After extraction of the contours of the object, the dimensions are calculated and displayed. The dimension of the object is calculated by the product of the pixel length of the object and PPM (pixel per metre). PPM can be calculated using any reference object whose dimensions are known to the system beforehand. In this case, the aruco marker is used as our reference object.

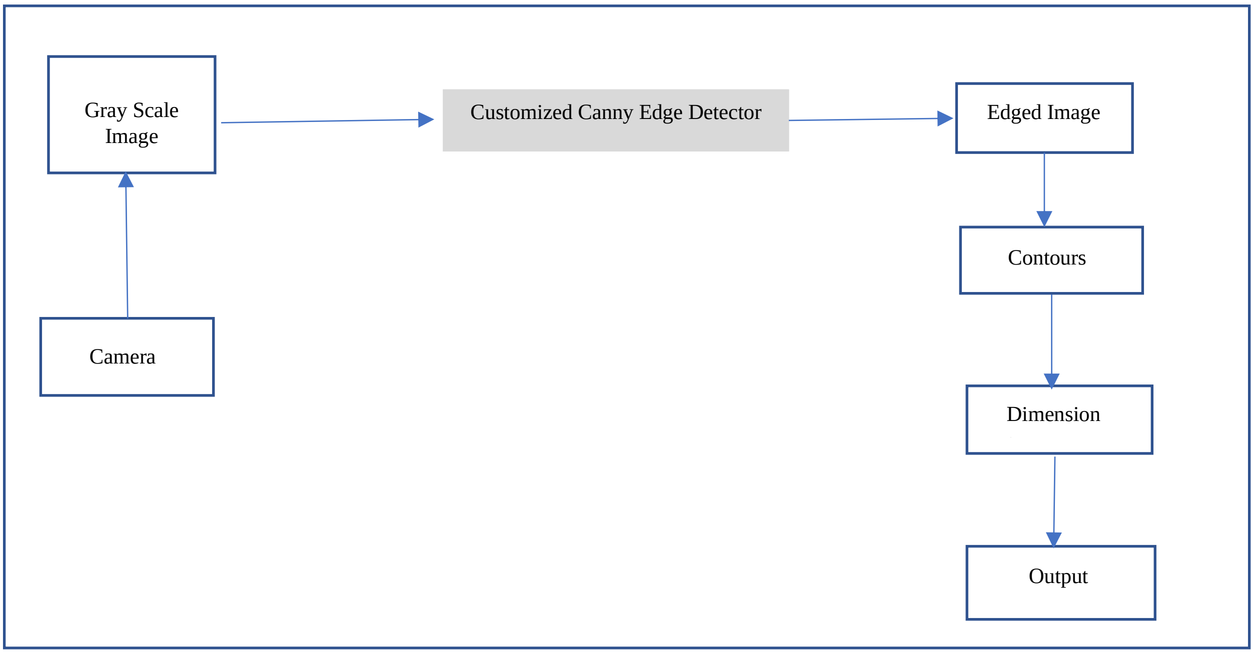

Fig. 2 Proposed system

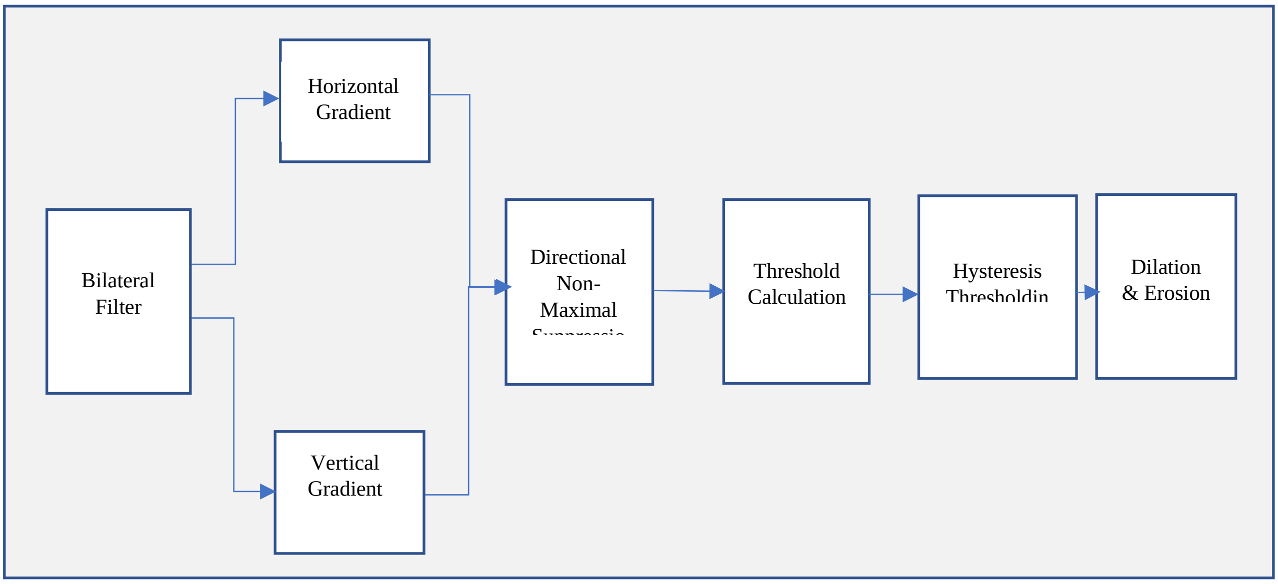

Fig. 3 Customized canny edge detector

5. Experimental Setup

For this system, the following are the externals/hardware used:

5.1. Camera (ASUS Webcam C3)

Fig. 4 Asus Webcam C3

The ASUS USB Webcam C3 records in 1080p 30 fps and has a clip that can be adjusted to fit a wide variety of devices. This camera offers crisp FHD (1920 x 1080) video production with fluid 30 frames per second.

5.2. Aruco Marker

As Aruco Marker is a precise square measuring 5 cm by 5 cm, there is an important advantage of not having to calibrate the camera.

Additionally, it is recognized by OpenCV and does not require any complicated processes for integration. Only the marker and the items need to be in the video.

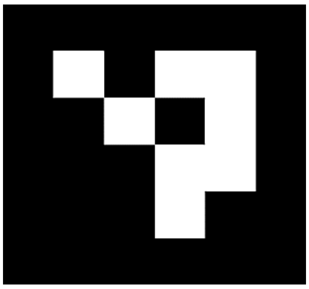

Fig. 5 Aruco Marker

5.3. CCEDA Algorithm with Pseudocode

Input : Real-Time Image(I),diameter of pixel(b1), sigma_color(b2), sigma_space(b3), Canny staring threshold (strong_th), Canny Weak threshold(weak_th), 5x5 matrix of ones (kernel), no_of_repetitions (iterations), Minimum Area (minArea)

Output: Image with Height and Width

Algorithm

```
{Customized Canny Edge}
img = GrayScale(image)
  img = BilateralFilter(img,b1,b2,b3)
  gx = Sobel_x(img)
  gy = Sobel_y(img)
  mag, ang = gx, gy{Converting Cartesian to polar}
  mag_max = maximum(mag)
  width,height = img.shape
  # Looping over each grayscale pixel
  for each i_x in (width of img) do
     for each i_y in range(height of img) do
        grad_ang = GradientAngle(i_y, i_x)
        neighbo_1_x, neighbo_1_y =
NeighbourPixel(grad_ang)
        neighbo_2_x, neighbo_2_y =
NeighbourPixel(grad_ang)
       # Non-max suppression layer step
        if width>neighbo_1_x>= 0 and
height>neighbo_1_y>= 0 then
           if mag[i_y, i_x]<mag[neighbo_1_y,
neighbo_1_x] then
              mag[i_y, i_x]= 0
        End if
        if width>neighbo_2_x>= 0 and
height>neighbo_2_y>= 0 then
           if mag[i_y, i_x]<mag[neighbo_2_y,
neighbo_2_x] then
              mag[i_y, i_x]= 0
        End if

mag=NonMaximumSuppression(mag,neighbo_1_x,neighb
o_1_y,
              neighbo_2_x,neighbo_2_y)
     End for
  End for
mag =
Double_Thresholding(mag,grad_mag,strong_th,weak_th,i
mg)
  imgCanny = mag
  imgDial = Dilation(imgCanny,kernel,iterations)
  imgEro = Erosion(imgDial,kernel,iterations)
  contours,hiearchy = FindContours(imgEro)
  for each cnt in contours do
    area = contourArea(cnt)
  if area > minArea then
    add cnt in contours
  End if
  End for
 aruco_perimeter = Perimeter(Aruco_Marker)
 pixel_cm_ratio = aruco_perimeter / Actual_perimeter
 for each cnt in contours do
  # Get rectangle
  rect = minAreaRectangle(cnt)
  (x, y), (w, h), angle = rect
  obj_width = w / pixel_cm_ratio
  obj_height = h / pixel_cm_ratio
End for
Return obj_width, obj_height
```

6. Results and Discussion

The web camera is used to capture images in real time and has performed dimension detection on them. The system is implemented using OpenCV and Python libraries, which provide all the necessary inbuilt methods to use.

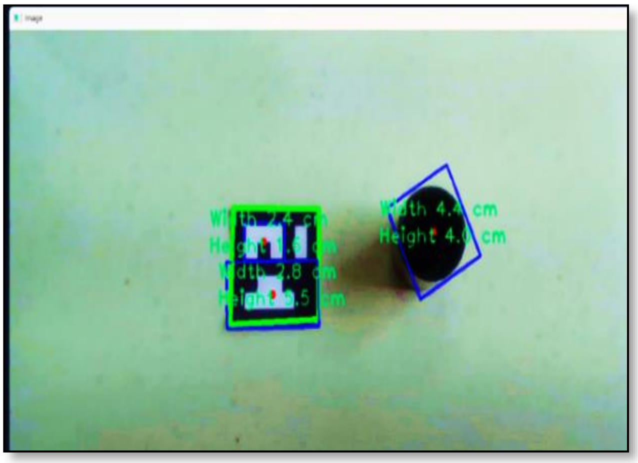

Fig. 6 Output-1

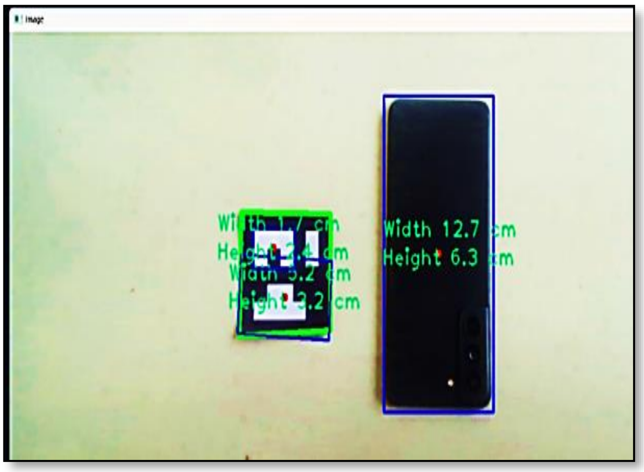

Fig. 7 Output-2

Table 1. Accuracy table

Object	Actual Height	Detected Height	Actual Width	Detected Width	Accuracy
Mobile	15	12.7	7	6.3	87.33
Credit Card	7	6.9	5	4.6	95.28
Cylindrical Cap	4.2	4.4	4.2	4	95.23
Apple logo	3.8	3.5	3	2.6	89.38
Smart Watch	3.5	3	1.5	1.5	92.85

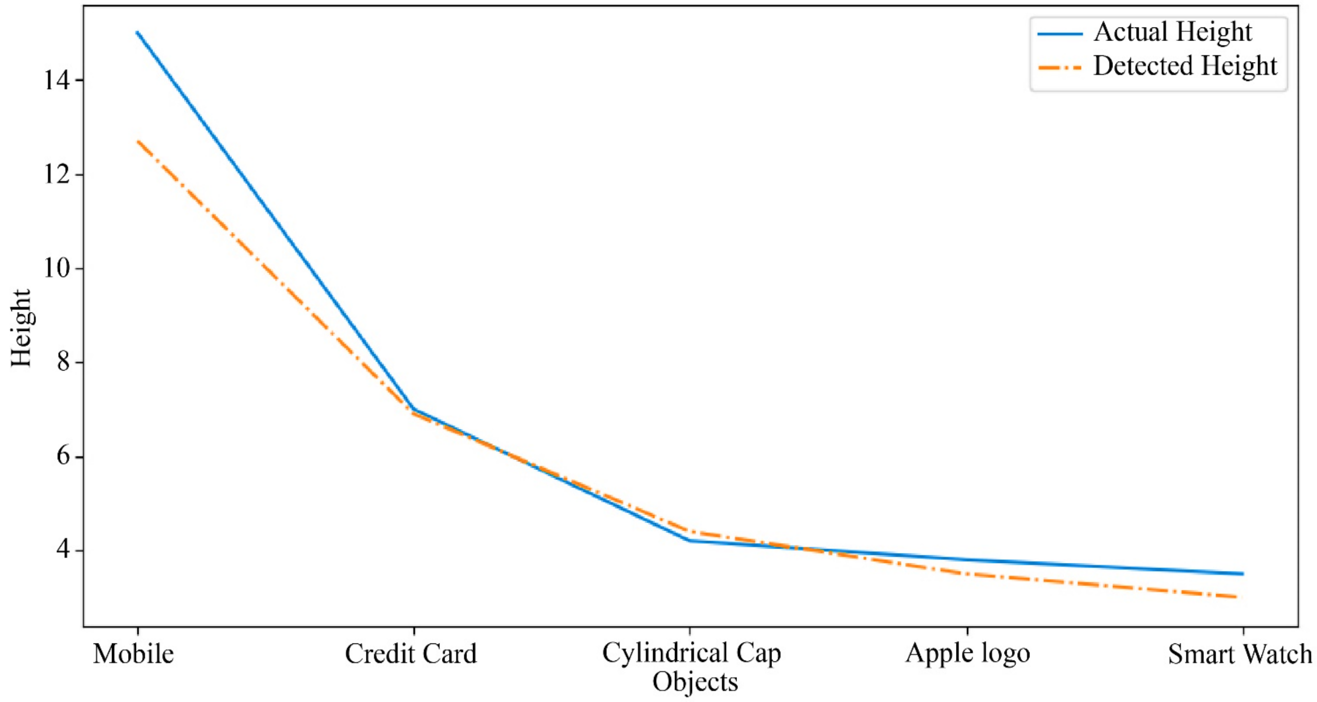

Fig. 8 Comparison between actual height and detected height

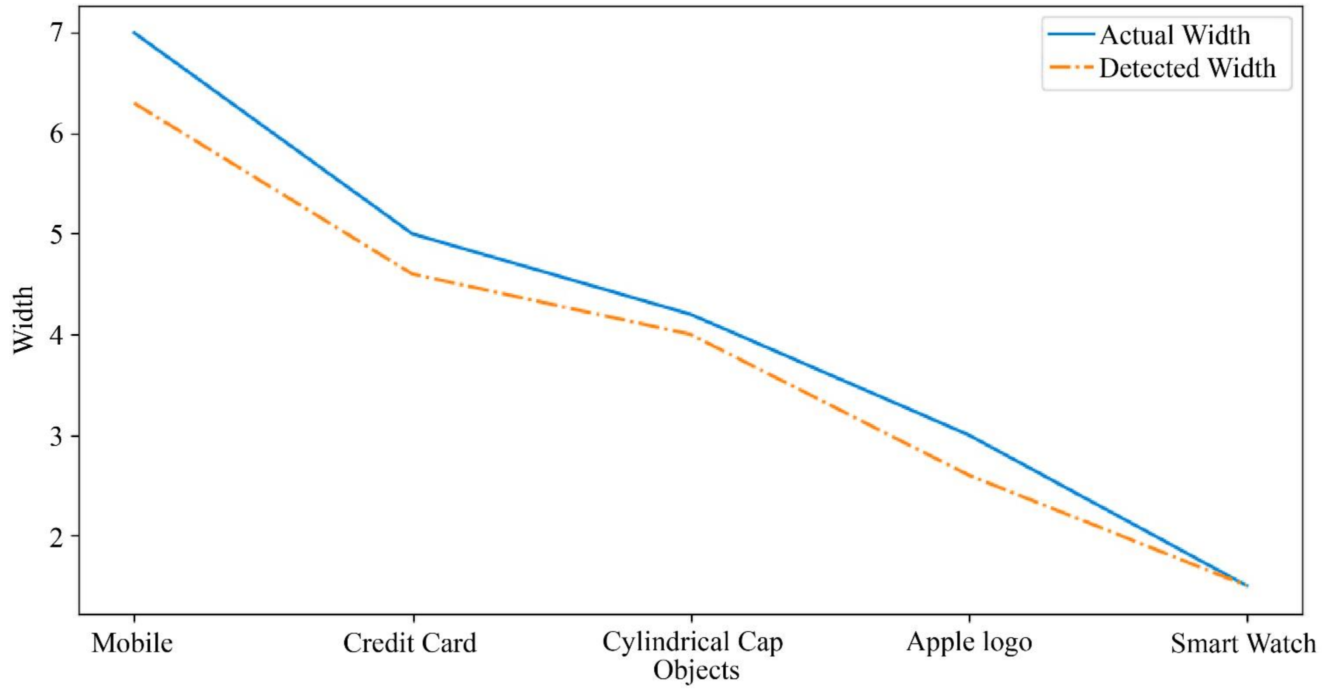

Fig. 9 Comparison between actual width and detected width

7. Comparative Analysis

Edge detection on several operators was evaluated, including sobel, prewitt, robert, Laplacian of Gaussian, canny, and our modified canny edge detector. The five metrics used for operator comparison are SNR, PSNR, Entropy, SSIM, and MSE. Hence, the better performance of modified canny edge detectors came into the picture. As per prior knowledge, a canny edge detector is the best one when it comes to edge detection for dimensions. The performance increase in the modified canny edge detector was observed upon integration with bilateral filter and morphological operations like dilation and erosion.

7.1. Parameters to Compare

The edge detection techniques are examined in this study using five parameters: PSNR, MSE, SNR, and SSIM [16-18, 22].

7.1.1. Entropy

Information obtained from a picture is measured by Shannon's entropy. Entropy, which measures the degree of unpredictability in an image on a technical level, is highly helpful in determining how relevant a processed image is [17].

7.1.2. PSNR

Peak signal-to-noise ratio (PSNR) is an expression for the ratio of signal power to noise power, and PSNR is represented in decibels. It is necessary to compare a picture's PSNR to a true, clean image with the highest possible power [16, 18].

7.1.3. MSE

The difference between actual and predicted outcomes is the model's error [16]. The average of all the disparities between actual and anticipated values is called MSE.

7.1.4. SNR

When signal power is compared to noise power, the signal-to-noise ratio is calculated [18].

7.1.5. SSIM

In order to compare two images, a statistic known as the structural similarity index measure is used; it primarily pulls properties like brightness, contrast, and structure to compare the photos. The range of SSIM's value is -1 to +1. The provided photographs are indicated by a +1 or a -1 depending on how similar or identical they are to one another.

Table 2. Comparative analysis between various metrices

	SNR	SSIM	Entropy	PSNR	MSE
Sobel	1.4683	0.0329	5.9314	27.8918	105.6575
Prewitt	0.3929	0.0526	4.0111	27.8951	105.5761
Robert	0.4834	0.0022	6.3601	27.6896	110.6905
Laplacian	0.4111	0.0313	3.1571	27.9054	105.3268
Canny	0.2216	0.0038	0.2728	27.9129	105.1442
Modified Canny	0.3353	0.0076	1.2635	27.9241	104.8737

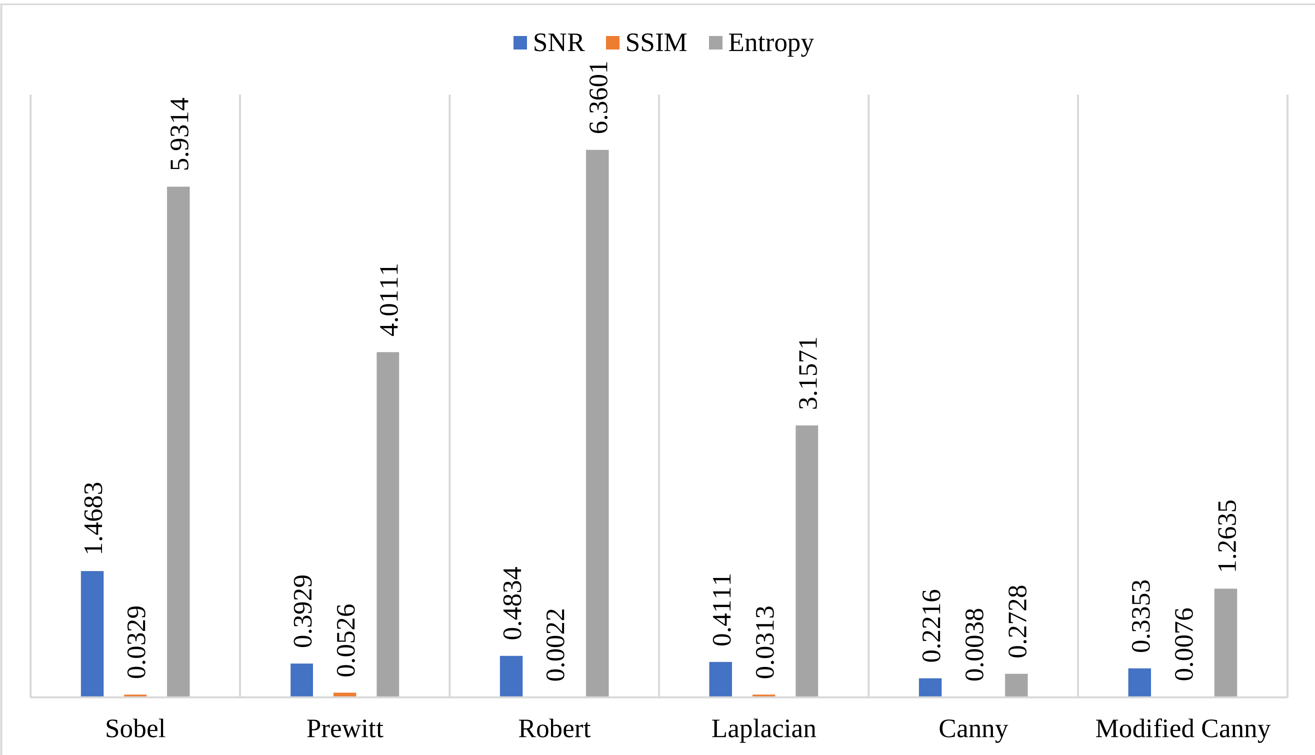

Fig. 10 Comparative analysis between SNR, SSIM, and Entropy with a modified canny edge detector

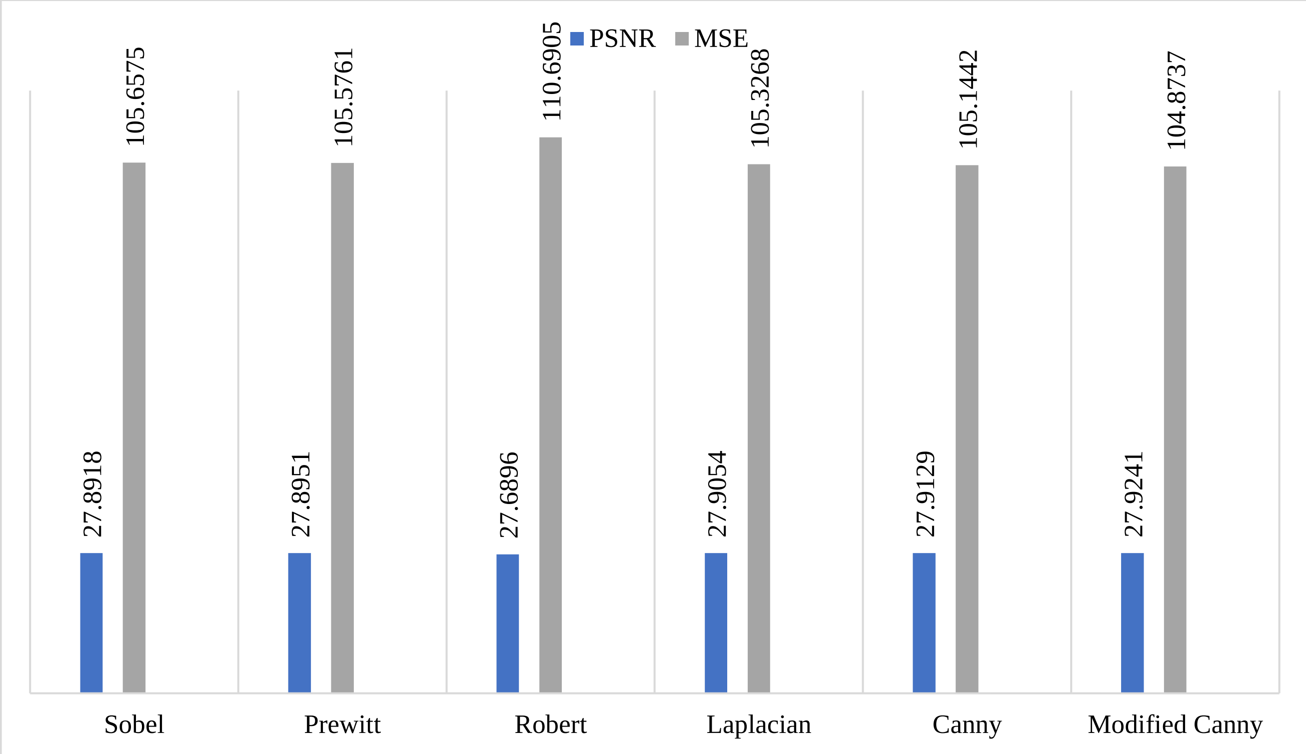

Fig. 11 Comparative analysis between PSNR, MSE with Customized canny edge detector

8. Conclusion

This paper focuses on real-time dimension detection by using a customized canny edge detector. The common checking-out accuracy of the model is 92.01%. The primary benefit of using this proposed model is that it will increase the effectuality of edge detection in its preliminary stages, which performs a necessary position in discovering contours and makes the whole technique more accurate. The computerized calculation of dimension objects from actual time images will supply a correct dimension estimate that can assist consumers in making industrial operations faster. Our device works higher for images with the decision of 1280 x 720. This system no longer solely helps consumers get speedy estimates of the object's dimensions. With further improvement in the canny edge detector, the system should be capable of predicting the dimensions more accurately and at a better speed. Adding morphological operations in the canny part detector resulted in higher surface detection at the speed value.

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